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Session 2B: Sediments and Nutrients

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SESSION 2B: SEDIMENTS AND NUTRIENTS

WATER, SEDIMENT, AND NUTRIENTS DATA STREAMS IN A FLUVIOKARST WATERSHED IN THE KENTUCKY BLUEGRASS: INSIGHTS FROM ELEMENTAL, ISOTOPIC, AND HIGH RESOLUTION SENSOR DATA

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The physical and biochemical fate of contaminants within karst systems is poorly understood. The gap in knowledge is of particular concern given the susceptibility of karst waters to contamination and their wide use as a water source. In Kentucky, approximately 55% of the land surface is underlain by rock with karst potential and close to two million Kentuckians access groundwater reserves for drinking water purposes. Data streams in karst systems are typically collected at arbitrarily selected wells and the terminal springhead, but due to the spatially heterogeneous nature of karst terrain and the high connectivity between surface and subsurface pathways these locations may not adequately characterize contaminant fate. Few studies have long-term water quality data at highly coupled surface and subsurface locations within a fluviokarst aquifer.

The objective of this study was to elucidate the pathways of water within karst systems, the biochemical processing and temporary storage of contaminants, and the fate of terrestrially derived matter within the subsurface. To that end, we collect spatial and temporal data over the course of half a decade (ranging from hourly storm data to bi-weekly integrated data) from surface tributaries feeding the karst system, the longitudinal midpoint of the subsurface conduit, and the primary spring. Event-based sampling highlights the physical transport and turbulent mixing of karst pathways, low-flow sampling isolates in-conduit biochemical processes from surface recharge, and long-term bi-weekly sampling indicates seasonal and yearly trends in water quality data. Samples were analyzed for sediment carbon (C) and nitrogen (N), stable C and N isotope composition of sediment ($\delta^{13}C_{Sed}$ & $\delta^{15}N_{Sed}$), nitrate (NO_3^-), oxygen (O) and N isotope composition of NO_3^- ($\delta^{15}N_{NO3}$ & $\delta^{18}O_{NO3}$), hydrogen (H) and O isotope composition of water ($\delta^{2}H_{H2O}$ & $\delta^{18}O_{H2O}$), and C isotope composition of dissolved inorganic C ($\delta^{13}C_{DIC}$). In addition, high resolution sensor data streams were analyzed from the primary springhead.

Results emphasize the role of pathway mixing and karst storage in controlling contaminant flux from the karst watershed. Further results indicate biochemical enrichment of heavier isotopes within the surficial fine-grained laminae (SFGL) of the karst conduit. The authors encourage karst watershed scientists to consider variable flow pathways and the impact of the SFGL on sediment and nutrient delivery to improve the accuracy of model predictions and aquifer assessment.

EFFECTS OF STREAM RESTORATION ON POLLUTANT LOAD REDUCTIONS IN AN URBAN WATERSHED

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Streams draining urban lands consistently suffer from "urban stream syndrome" (Walsh et al., 2005), which is characterized by flashy hydrology, elevated concentrations of nutrients and contaminants, altered morphology, decreased amounts of organic matter, and poor biotic richness. Urban streams are often incised, over widened, lack bed complexity, have small hyporheic zones, have narrow floodplain corridors bordered by structures and utilities, and lack woody material. Restoring urban streams is a challenging endeavor, particularly when restoration goals include water quality and habitat improvements, the top two components of the Stream Functions Pyramid (Harman et al., 2012). Notable water quality impairments in many urban streams include elevated nutrient, sediment, and pathogen concentrations (Walsh et al., 2005). Of particular concern is nitrogen (N) and phosphorus (P) as these two constituents, in excess levels, promote eutrophication. In the U.S., eutrophication is one of the leading water quality impairments (Sharpley et al., 2003). Stormwater best management practices focus on reducing pollutant loads from upland sources, but do not address pollutant removal in the stream itself. Restoring the hyporheic zone, particularly through the addition of woody material in the floodplain, could promote retention and processing of instream pollutants (Valett et al., 1996).

In 2013, a nearly 950 ft of an unnamed headwater tributary (UT) to the South Elkhorn Creek at the Montessori Middle School of Kentucky (MMSK) was restored using regenerative design techniques whereby a floodplain-wetland complex was created. The restoration resulted in a wide, wetland-like floodplain, comprised of a rock base that was overtopped with a filtration media (approximately 30% woodchips and 70% topsoil). This combination of regenerative design and woody material addition to floodplain soils, may improve the quality of downstream receiving waters indicating such stream restoration efforts may serve as a viable TMDL.

The **purpose** of this work is to determine the effectiveness of using regenerative design techniques coupled with a designed filter media to improve water quality of urban streams. **Specific objectives** of the project are to: 1) determine the effect of the MMSK stream restoration project on hydrology, 2) determine the ability of the MMSK stream restoration project to improve water quality, and 3) educate water managers, design professionals, and other stakeholders on strategies to restore urban streams and improve water quality.

Prior to restoration, the University of Louisville (U of L) Stream Institute monitored the hydrology (storm and base flows) and water quality (PO_4-P, NO_3+NO_2-N, NH_3-N, BOD, pH, EC, and DO) at three locations on the stream (see Figure 1) for a one-year period (Parola et al., 2013). These data were provided to the PIs by the U of L Stream Institute. The upstream and downstream extents of the project are equipped with trapezoidal flumes and stage height recorders (HOBO water level loggers) for continuous discharge measurements. Floodplain cross-sections, at the upstream and downstream weirs, were surveyed to develop stage-discharge relationships when flood stage exceeds weir capacity. Three well transects, each consisting of six wells were installed along the project reach to evaluate water levels and constituent concentrations within the restored floodplain. Water levels within the wells are measured bi-weekly. During equipment installation, it was noted that two pipes, 24-inch and 42-inch diameters, discharged into the project reach. Discharge in both pipes is measured using ISCO 4250 flow meters (one per pipe). Bi-weekly grab samples are collected from the three locations along the stream (upstream, downstream, and middle) and the wells and analyzed for PO_4-P, NO_3-N/NO_2-N, NH_3-N, Cl^-, SO_4, TOC, DOC, *E.coli* (stream only), TSS, and turbidity using standard methods (APHA, 1992). Bi-weekly, *in situ* measurements of pH, EC, DO, and temperature (measured using a YSI 556 multiprobe system) are taken at the three stream sample locations and at each well. A rain gauge was installed at the project site to provide precipitation data.

Data collection in actively on-going and is expected to conclude summer of 2018. Comparisons between upstream, middle, and downstream hydrology and instream water quality will be conducted following the completion of the data collection period.

WATERSHED SEDIMENT TRANSPORT MODELING USING DYNAMIC LATERAL, LONGITUDINAL, AND VERTICAL SEDIMENT (DIS)CONNECTIVITY

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Recent geomorphologic literature suggests that sediment (dis)connectivity, which describes the detachment and transport of sediment from source to sink in the lateral, longitudinal, and vertical directions between geomorphic zones, is a major control on sediment transport. However, we find that few contemporary sediment transport and watershed erosion models incorporate sediment connectivity concepts and in the present study, we advance this modeling framework by applying the model to a lowland, bedrock-controlled catchment in Kentucky, USA. Bedrock controlled catchments are potentially unique due to the presence of bedrock outcrops, which cause longitudinal impedance to sediment transport within the stream corridor. We argue that given the now widespread availability of high-resolution topographic and landscape feature datasets, the time is ripe to advance watershed and sediment transport modeling *via* the improvement of the spatiotemporal setting. Therefore, this study was motivated by the need to formulate a sediment transport model that couples sediment (dis)connectivity knowledge with erosion and transport equations to predict sediment flux for bedrock-controlled catchments.

This modeling framework couples a watershed-scale erosion model with an instream sediment transport model that incorporates sediment (dis)connectivity knowledge from field reconnaissance and GIS analyses. Upland sediment connectivity is predicted and reflects the co-occurrence of both hydrologic and non-hydrologic sediment detachment and transport, sediment supply availability, and disconnectivity. The integration of the net watershed probability of connectivity yields an estimate of the active watershed area in terms of upland sediment transport when multiplied times the entire watershed area. Within the stream corridor, we simulate connectivity by discretizing fluid and sediment pathways due to barriers that impede longitudinal sediment transport such as bedrock outcrops and manmade check dams. Discretization of the reaches was aided by field reconnaissance and visual stream assessments. The instream model predicts erosion and deposition of sediment from the bed, banks, and SFGL within each reach and sediment yield at the watershed outlet at the ten-minute time step.

The simulated sediment flux was calibrated and validated using the existing historic sediment dataset collected by the authors. The probability of sediment connectivity model highlights the disconnected nature of the upland ephemeral network within the watershed. In general, the model predicted that little connectivity occurs over the course of the year within the uplands and only 13% of the catchment contributed sediment to the stream network on the most connected day of the year. Furthermore, this modeling effort hopes to show how the digitization of the bedrock outcrops affects erosion and deposition rates within the stream corridor and how the explicit simulation of upland sediment erosion impacts the transport capacity of the fluid. This research is applied to the Upper South Elkhorn watershed, a lowland, bedrock-controlled catchment in the Bluegrass Region of Kentucky, USA. Through this study, we hope to elucidate further the governing processes that dictate sediment transport in lowland, bedrock-controlled catchments. Given the recognized importance of lowland catchments in worldwide sediment yields, investigating these processes will assist future consultants and researchers in managing water supply and water quality.